intel *Development Solutions*

# ASM86
# Pocket Reference
# for DOS Systems

Order Number: 122387-001

## CONTENTS



## Notational Conventions

color — Indicates user input for interactive examples.

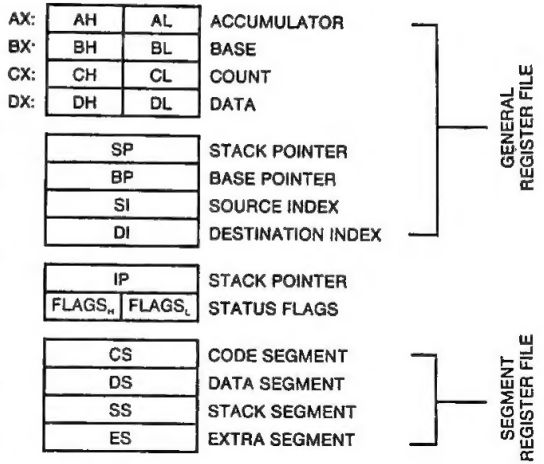
[ ] — Brackets indicate optional arguments or parameters.

<cr> — Indicates a carriage return.

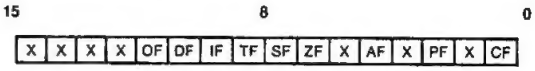




## 8086 Register Model




Instructions that reference the flag register file as a 16-bit object use the symbol FLAGS to represent the file:




X = Don't Care

## Flags

AF: AUXILIARY CARRY — BCD
CF: CARRY FLAG
DF: DIRECTION FLAG (STRINGS)
IF: INTERRUPT ENABLE FLAG
OF: OVERFLOW FLAG (CF SF)
PF: PARITY FLAG
SF: SIGN FLAG
TF: TRAP (SINGLE STEP FLAG)
ZF: ZERO FLAG

## Operand Summary

**"reg" field Bit Assignments:**

| Word Operand | Byte Operand | Segment |
|---|---|---|
| 000 AX | 000 AL | 00 ES |
| 001 CX | 001 CL | 01 CS |
| 010 DX | 010 DL | 10 SS |
| 011 BX | 011 BL | 11 DS |
| 100 SP | 100 AH | |
| 101 BP | 101 CH | |
| 110 SI | 110 DH | |
| 111 DI | 111 BH | |

## Second Instruction Byte Summary

| mod xxx r/m |
|---|

| mod | Displacement |
|---|---|
| 00 | DISP = 0*, disp-low and disp-high are absent |
| 01 | DISP = disp-low sign-extended to 16-bits, disp-high is absent |
| 10 | DISP = disp-high: disp-low |
| 11 | r/m is treated as a "reg" field |

| r/m | Operand Address |
|---|---|
| 000 | (BX) + (SI) + DISP |
| 001 | (BX) + (DI) + DISP |
| 010 | (BP) + (SI) + DISP |
| 011 | (BP) + (DI) + DISP |
| 100 | (SI) + DISP |
| 101 | (DI) + DISP |
| 110 | (BP) + DISP* |
| 111 | (BX) + DISP |

DISP follows 2nd byte of instruction (before data if required).

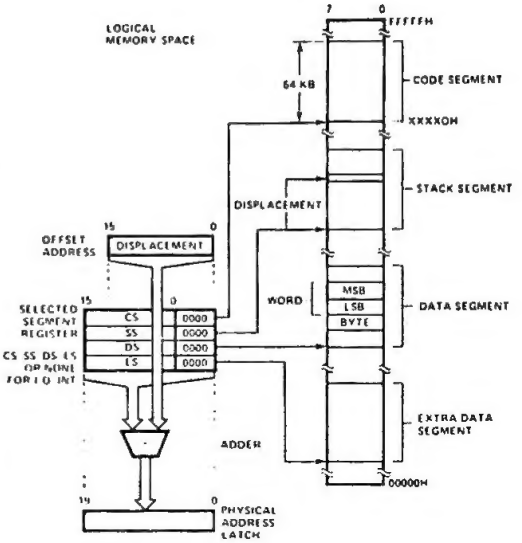
*except if mod = 00 and r/m = 110 then EA = disp-high: disp-low.

## Operand Address (EA) Timing (Clocks):

Add 4 clocks for word operands at ODD ADDRESSES.
Immed Offset = 6
Base (BX, BP, SI, DI) = 5
Base + DISP = 9
Base + Index (BP + DI, BX + SI) = 7
Base + Index (BP + SI, BX + DI) = 8
Base + Index (BP + DI, BX + SI) + DISP = 11
Base + Index (BP + SI, BX + DI) + DISP = 12



## Memory Segmentation Model




## Segment Override Prefix

| 0 0 1 reg 1 1 0 |
|---|

Timing: 2 clocks

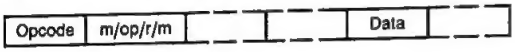
## Use of Segment Override

| Operand Register | Default | With Override Prefix |
|---|---|---|
| IP (code address) | CS | Never |
| SP (stack address) | SS | Never |
| BP (stack address or stack marker) | SS | BP + DS or ES, or CS |
| SI or DI (not incl. strings) | DS | ES, SS, or CS |
| SI (implicit source addr for strings) | DS | ES, SS, or CS |
| DI (implicit dest addr for strings) | ES | Never |

## 8086/8088 Instructions

### Notes for 8086/8088 Instructions

The individual instruction descriptions are shown by a format box such as the following:

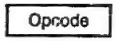



These are byte-wise representations of the object code generated by the assembler and are interpreted as follows:

- Opcode is the 8-bit opcode for the instruction. The actual opcode generated is defined in the "Opcode" column of the instruction table that follows each format box.
- m/op/r/m is the byte that specifies the operands of the instruction. It contains a 2-bit mode field (m), a 3-bit register field (op), and a 3-bit register or memory (r/m) field.
- Dashed blank boxes following the m/op/r/m box are for any displacement required by the mode field.
- Data is for a byte of immediate data.
- A dashed blank box following a Data box is used whenever the immediate operand is a word quantity.

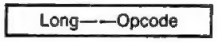


### AAA = ASCII Adjust for Addition



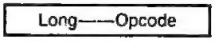

| Opcode | Clocks | Operation |
|---|---|---|
| 37 | 4 | adjust AL, flags, AH |

### AAD = ASCII Adjust for Division



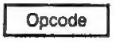

| Opcode | Clocks | Operation |
|---|---|---|
| D5,0A | 60 | Adjust AL, AH prior to division |

### AAM = ASCII Adjust for Multiplication




| Opcode | Clocks | Operation |
|---|---|---|
| D4,0A | 83 | Adjust AL, AH after multiplication |

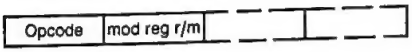
### AAS = ASCII Adjust for Subtraction




| Opcode | Clocks | Operation |
|---|---|---|
| 3F | 4 | adjust AL, flags, AH |

## ADC = Integer Add with Carry

### Memory/Reg + Reg

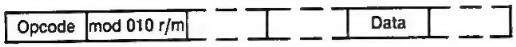



| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 12 | 3 | Reg8 ← CF + Reg 8 + Reg8 |
| | 12 | 9+EA | Reg8 ← CF + Reg8 + Mem8 |
| | 10 | 16+EA | Mem8 ← CF + Mem8 + Reg8 |
| Word | 13 | 3 | Reg16 ← CF + Reg16 + Reg16 |
| | 13 | 9+EA | Reg16 ← CF + Reg16 + Mem16 |
| | 11 | 16+EA | Mem16 ← CF + Mem16 + Reg16 |

### Immed to AX/AL


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 14 | 4 | AL ← CF + AL + Immed8 |
| Word | 15 | 4 | AX ← CF + AX + Immed16 |

### Immed to Memory/Reg

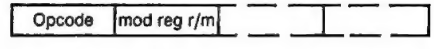



| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 80 | 4 | Reg8 ← CF + Reg8 + Immed8 |
| | 80 | 17+EA | Mem8 ← CF + Mem8 + Immed8 |
| Word | 81 | 4 | Reg16 ← CF + Reg16 + Immed16 |
| | 81 | 17+EA | Mem16 ← CF + Mem16 + Immed16 |
| | 83 | 4 | Reg16 ← CF + Reg16 + Immed8 |
| | 83 | 17+EA | Mem16 ← CF + Mem16 + Immed8 |



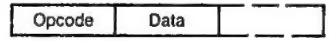
## ADD = Integer Addition

### Memory/Reg + Reg



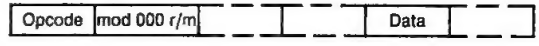

| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 02 | 3 | Reg8 ← Reg8 + Reg8 |
| | 02 | 9+EA | Reg8 ← Reg8 + Mem8 |
| | 00 | 16+EA | Mem8 ← Mem8 + Reg8 |
| Word | 03 | 3 | Reg16 ← Reg16 + Reg16 |
| | 03 | 9+EA | Reg16 ← Reg16 + Mem16 |
| | 01 | 16+EA | Mem16 ← Mem16 + Reg16 |

### Immed to AX/AL




| Opcode | Clocks | Operation |
|---|---|---|
| 04 | 4 | AL ← AL + Immed8 |
| 05 | 4 | AX ← AX + Immed16 |

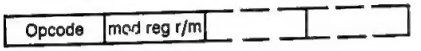
### Immed to Memory/Reg




| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 80 | 4 | Reg8 ← Reg8 + Immed8 |
| | 80 | 17+EA | Mem8 ← Mem8 + Immed8 |
| Word | 81 | 4 | Reg16 ← Reg16 + Immed16 |
| | 81 | 17+EA | Mem16 ← Mem16 + Immed16 |
| | 83 | 4 | Reg16 ← Reg16 + Immed8 |
| | 83 | 17+EA | Mem16 ← Mem16 + Immed8 |

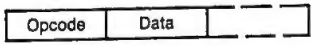
## AND = Logical AND

### Memory/Reg with Reg



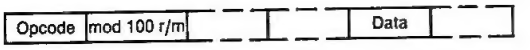

| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 22 | 3 | Reg8 ← Reg8 AND Reg8 |
| | 22 | 9+EA | Reg8 ← Reg8 AND Mem8 |
| | 20 | 16+EA | Mem8 ← Mem8 AND Reg8 |
| Word | 23 | 3 | Reg16 ← Reg16 AND Reg16 |
| | 23 | 9+EA | Reg16 ← Reg16 AND Mem16 |
| | 21 | 16+EA | Mem16 ← Mem16 AND Reg16 |

### Immed to AX/AL




| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 24 | 4 | AL ← AL AND Immed8 |
| Word | 25 | 4 | AX ← AX AND Immed16 |

### Immed to Memory/Reg




| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 80 | 4 | Reg8 ← Reg8 AND Immed8 |
| | 80 | 17+EA | Mem8 ← Mem8 AND Immed8 |
| Word | 81 | 4 | Reg16 ← Reg16 AND Immed16 |
| | 81 | 17+EA | Mem16 ← Mem16 AND Immed16 |

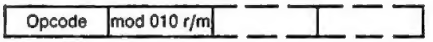


## CALL = Call

### Within segment or group, IP relative

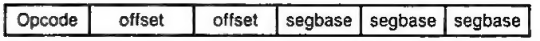

| Opcode | Clocks | Operation |
|---|---|---|
| E8 | 19 | IP ← IP+Disp16—(SP) ← return link |

### Within segment or group, Indirect



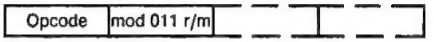

| Opcode | Clocks | Operation |
|---|---|---|
| FF | 16 | IP ← Reg16—(SP) ← return link |
| FF | 21+EA | IP ← Mem16—(SP) ← return link |
| FF | 21+EA | IP ← Mem16—(SP) ← return link |

### Inter-segment or group, Direct



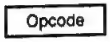

| Opcode | Clocks | Operation |
|---|---|---|
| 9A | 28 | CS ← segbase<br>IP ← offset |

### Inter-segment or group, Indirect



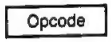

| Opcode | Clocks | Operation |
|---|---|---|
| FF | 37+EA | CS ← segbase<br>IP ← offset |

## CBW = Convert Byte to Word




| Opcode | Clocks | Operation |
|---|---|---|
| 98 | 2 | convert byte in AL to word in AX |

## CLC = Clear Carry Flag




| Opcode | Clocks | Operation |
|---|---|---|
| F8 | 2 | clear the carry flag |

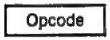
## CLD = Clear Direction Flag


| Opcode | Clocks | Operation |
|---|---|---|
| FC | 2 | clear direction flag |

## CLI = Clear Interrupt Enable Flag

| Opcode | Clocks | Operation |
|---|---|---|
| FA | 2 | clear interrupt flag |

## CMC = Complement Carry Flag

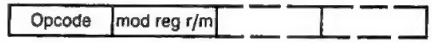



| Opcode | Clocks | Operation |
|---|---|---|
| F5 | 2 | complement carry flag |



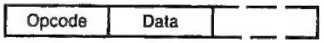
## CMP = Compare Two Operands

### Memory/Reg with Reg



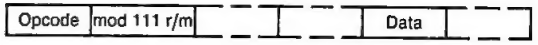

| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 38 | 3 | flags ← Reg8 - Reg8 |
| | 38 | 9+EA | flags ← Reg8 - Mem8 |
| | 3A | 9+EA | flags ← Mem8 - Reg8 |
| Word | 39 | 3 | flags ← Reg16 - Reg16 |
| | 39 | 9+EA | flags ← Reg16 - Mem16 |
| | 3B | 9+EA | flags ← Mem16 - Reg16 |

### Immed to AX/AL



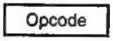

| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 3C | 4 | flags AL - Immed8 |
| Word | 3D | 4 | flags AX - Immed16 |

### Immed to Memory/Reg



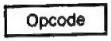

| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 80 | 4 | flags ← Reg8 - Immed8 |
| | 80 | 10+EA | flags ← Mem8 - Immed8 |
| Word | 81 | 4 | flags ← Reg16 - Immed16 |
| | 81 | 10+EA | flags ← Mem16 - Immed16 |
| | 83 | 4 | flags ← Reg16 - Immed8 |
| | 83 | 10+EA | flags ← Mem16 - Immed8 |

## CWD = Convert Word to Doubleword



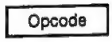

| Opcode | Clocks | Operation |
|---|---|---|
| 99 | 5 | convert word in AX to doubleword in DX:AX |

## DAA = Decimal Adjust for Addition




| Opcode | Clocks | Operation |
|---|---|---|
| 27 | 4 | adjust AL, flags, AH |

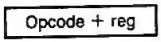
## DAS = Decimal Adjust for Subtraction




| Opcode | Clocks | Operation |
|---|---|---|
| 2F | 4 | adjust AL, flags, AH |

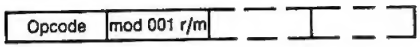
## DEC = Decrement by 1

Word Register




| Opcode | Clocks | Operation |
|---|---|---|
| 48+reg | 2 | Reg16 ← Reg16 - 1 |

Memory/Byte Register

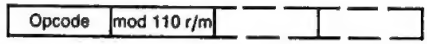



| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | FE | 3 | Reg8 ← Reg8 - 1 |
| | FE | 15+EA | Mem8 ← Mem8 - 1 |
| Word | FF | 15+EA | Mem16 ← Mem16 - 1 |



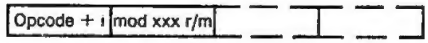
## DIV = Unsigned Division

Memory/Reg with AX or DX:AX



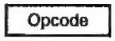

| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | F6 | 80-90 | AH,AL ← AX / Reg8 |
| | F6 | (86-96)+EA | AH,AL ← AX / Mem8 |
| Word | F7 | 144-162 | DX,AX ← DX:AX / Reg16 |
| | F7 | (150-168)+EA | DX,AX ← DX:AX / Mem16 |

## ESC = Escape




| Opcode | Clocks | Operation |
|---|---|---|
| D8+i | 8+EA | data bus ← (EA) |
| D8+i | 2 | data bus ← (EA) |

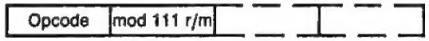
## HLT = Halt




| Opcode | Clocks | Operation |
|---|---|---|
| F4 | 2 | halt operation |

## IDIV = Signed Division

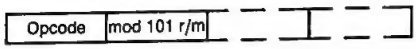
Memory/Reg with AX or DX:AX




| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | F6 | 101-112 | AH,AL ← AX / Reg8 |
| | F6 | (107-118)+EA | AH,AL ← AX / Mem8 |
| Word | F7 | 165-184 | DX,AX ← DX:AX / Reg16 |
| | F7 | (171-190)+EA | DX,AX ← DX:AX / Mem16 |

## IMUL = Signed Multiplication

Memory/Reg with AL or AX



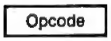

| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | F6 | 80-98 | AX ← AL*Reg8 |
| | F6 | (86-104)+EA | AX ← AL*Mem8 |
| Word | F7 | 128-154 | DX:AX ← AX*Reg16 |
| | F7 | (134-160)+EA | DX:AX ← AX*Mem16 |

## IN = Input Byte, Word

Fixed port


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | E4 | 10 | AL ← Port8 |
| | E5 | 10 | AX ← Port8 |

Variable port

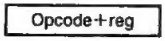



| | Opcode | Clocks | Operation |
|---|---|---|---|
| Word | EC | 8 | AL ← Port16(in DX) |
| | ED | 8 | AX ← Port16(in DX) |



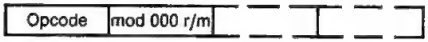
## INC = Increment by 1

Word Register




| Opcode | Clocks | Operation |
|---|---|---|
| 40+reg | 2 | Reg16 ← Reg16 + 1 |

Memory/Byte Register



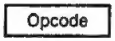

| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | FE | 3 | Reg8 ← Reg8 + 1 |
| | FE | 15+EA | Mem8 ← Mem8 + 1 |
| Word | FF | 15+EA | Mem16 ← Mem16 + 1 |

## INT<br>INTO = Interrupt




| Opcode | Clocks | Operation |
|---|---|---|
| CC | 52 | Interrupt 3 |
| CD | 51 | Interrupt 'type' |
| CE | 53 or 4 | Interrupt4 if FLAGS.OF=1, else NOP |

## IRET = Return from Interrupt




| Opcode | Clocks | Operation |
|---|---|---|
| CF | 24 | Return from interrupt |

## *Jcond* = Jump on Condition

### Operation

If condition is true then do;
  sign-extend displacement to 16 bits;
  IP ← IP + sign-extended displacement;
  end if;

### Format

| Opcode | Disp |
|---|---|

| Opcode | Clocks | Operation | *cond* = |
|---|---|---|---|
| 77 | 16 or 4 | jump if above | JA |
| 73 | 16 or 4 | jump if above or equal | JAE |
| 72 | 16 or 4 | jump if below | JB |
| 76 | 16 or 4 | jump if below or equal | JBE |
| 72 | 16 or 4 | jump if carry set | JC |
| 74 | 16 or 4 | jump if equal | JE |
| 7F | 16 or 4 | jump if greater | JG |
| 7D | 16 or 4 | jump if greater or equal | JGE |
| 7C | 16 or 4 | jump if less | JL |
| 7E | 16 or 4 | jump if less or equal | JLE |
| 76 | 16 or 4 | jump if not above | JNA |
| 72 | 16 or 4 | jump if neither above nor equal | JNAE |
| 73 | 16 or 4 | jump if not below | JNB |
| 77 | 16 or 4 | jump if neither below nor equal | JNBE |
| 73 | 16 or 4 | jump if no carry | JNC |
| 75 | 16 or 4 | jump if not equal | JNE |
| 7E | 16 or 4 | jump if not greater | JNG |
| 7C | 16 or 4 | jump if neither greater nor equal | JNGE |
| 7D | 16 or 4 | jump if not less | JNL |
| 7F | 16 or 4 | jump if neither less nor equal | JNLE |
| 71 | 16 or 4 | jump if no overflow | JNO |
| 7B | 16 or 4 | jump if no parity | JNP |
| 79 | 16 or 4 | jump if positive | JNS |
| 75 | 16 or 4 | jump if not zero | JNZ |
| 70 | 16 or 4 | jump if overflow | JO |
| 7A | 16 or 4 | jump if parity | JP |
| 7A | 16 or 4 | jump if parity even | JPE |
| 7B | 16 or 4 | jump if parity odd | JPO |
| 78 | 16 or 4 | jump if sign | JS |
| 74 | 18 or 6 | jump if zero | JZ |
| E3 | 18 or 6 | jump if CX is zero (does not test flags) | JCXZ |



## JMP = Jump

### Within segment or group, IP relative

| Opcode | DispL | DispH |
|---|---|---|

| Opcode | Clocks | Operation |
|---|---|---|
| E9 | 15 | IP ← IP + Disp16 |
| EB | 15 | IP ← IP + Disp8 (Disp8 sign-extended) |

### Within segment or group, Indirect

| Opcode | mod 100 r/m | | | |
|---|---|---|---|---|

| Opcode | Clocks | Operation |
|---|---|---|
| FF | 11 | IP ← Reg16 |
| FF | 18+EA | IP ← Mem16 |
| FF | 18+EA | IP ← Mem16 |

### Inter-segment or group, Direct

| Opcode | offset | offset | segbase | segbase |
|---|---|---|---|---|

| Opcode | Clocks | Operation |
|---|---|---|
| EA | 15 | CS ← segbase<br>IP ← offset |

### Inter-segment or group, Indirect

| Opcode | mod 101 r/m | | | |
|---|---|---|---|---|

| Opcode | Clocks | Operation |
|---|---|---|
| FF | 24+EA | CS ← segbase<br>IP ← offset |

## LAHF = Load AH from Flags

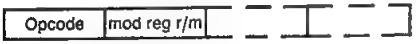
| Opcode |
|---|

| Opcode | Clocks | Operation |
|---|---|---|
| 9F | 4 | copy low byte of flags word to AH |

## LDS/LES = Load Pointer to DS/ES and Register

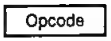

| Opcode | Clocks | Operation |
|---|---|---|
| C4 | 16+EA | dword pointer at EA goes to reg16 (1st word) and ES (2nd word) |
| C5 | 16+EA | dword pointer at EA goes to reg16 (1st word) and DS (2nd word) |

## LEA = Load Effective Address




| Opcode | Clocks | Operation |
|---|---|---|
| 8D | 2+EA | Reg16←EA |

## LOCK = Assert Bus Lock




| Opcode | Clocks | Operation |
|---|---|---|
| F0 | 2 | assert the bus lock next instruction |

## LOOP*xx* = Loop Control


| Opcode | Clocks | Operation | *xx* = |
|---|---|---|---|
| E1 | 18 or 6 | dec CX; loop if equal and CX not 0 | LOOPE |
| E0 | 19 or 5 | dec CX; loop if not equal and CX not 0 | LOOPNE |
| E1 | 18 or 6 | dec CX; loop if zero and CX not 0 | LOOPZ |
| E0 | 19 or 5 | dec CX; loop if not zero and CX not 0 | LOOPNZ |
| E2 | 17 or 5 | dec CX; loop if CX not 0 | LOOP |



## MOV = Move Data

### Memory/Reg to or from Reg


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 88 | 9+EA | Mem8←Reg8 |
| | 88 | 2 | Reg8←Reg8 |
| | 8A | 8+EA | Reg8←Mem8 |
| Word | 89 | 9+EA | Mem16←Reg16 |
| | 89 | 2 | Reg16←Reg16 |
| | 8B | 8+EA | Reg16←Mem16 |

### Direct-Addressed Memory to or from AX/AL


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | A0 | 10 | AL←Mem8 |
| | A2 | 10 | Mem8←AL |
| Word | A1 | 10 | AX←Mem16 |
| | A3 | 10 | Mem16←AX |

### Immed to Reg


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | B0+reg | 4 | Reg 8←Immed8 |
| Word | B8+reg | 4 | Reg16←Immed16 |

### Immed to Memory/Reg


| Opcode | Clocks | Operation |
|---|---|---|
| C6 | 4 | Reg8←Immed8 |
| C6 | 10+EA | Mem8←Immed8 |
| C7 | 4 | Reg16←Immed16 |
| C7 | 10+EA | Mem16←Immed16 |

Memory/Reg to or from SReg


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Word | 8C | 9+EA | Mem16←SReg |
| | 8C | 2 | Reg16←SReg |
| | 8E | 8+EA | SReg←Mem16 |
| | 8E | 2 | SReg←Reg16 |

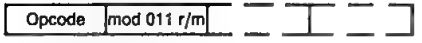
## MUL = Unsigned Multiplication

Memory/Reg with AL or AX


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | F6 | 70-77 | AX←AL*Reg8 |
| | F6 | (76-83)+EA | AX←AL*Mem8 |
| Word | F7 | 118-133 | DX:AX←AX*Reg16 |
| | F7 | (124-139)+EA | DX:AX←AX*Mem16 |

## NEG = Negate an Integer

Memory/Reg




| Opcode | Clocks | Operation |
|---|---|---|
| F6 | 3 | Reg8←00H - Reg 8 |
| F7 | 3 | Reg16←0000H - Reg16 |
| F6 | 16+EA | Mem8←00H - Mem8 |
| F7 | 16+EA | Mem16←0000H - Mem16 |

## NOP = No Operation


| Opcode | Clocks | Operation |
|---|---|---|
| 90 | 3 | no operation |



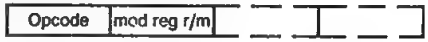
## NOT = Form One's Complement

Memory/Reg


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | F6 | 3 | Reg8←0FFH - Reg8 |
| | F6 | 16+EA | Mem8←0FFH - Mem8 |
| Word | F7 | 3 | Reg16←0FFFFH - Reg16 |
| | F7 | 16+EA | Mem16←0FFFFH - Mem16 |

## OR = Logical Inclusive OR

Memory/Reg with Reg




| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 0A | 3 | Reg8←Reg8 OR Reg8 |
| | 0A | 9+EA | Reg8←Reg8 OR Mem8 |
| | 08 | 16+EA | Mem8←Mem8 OR Reg8 |
| Word | 0B | 3 | Reg16←Reg16 OR Reg 16 |
| | 0B | 9+EA | Reg16←Reg16 OR Mem16 |
| | 09 | 16+EA | Mem16←Mem16 OR Reg16 |

Immed to AX/AL


| Opcode | Clocks | Operation |
|---|---|---|
| 0C | 4 | AL←AL OR Immed8 |
| 0D | 4 | AX←AX OR Immed16 |

Immed to Memory/Reg


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 80 | 4 | Reg8←Reg8 OR Immed8 |
| | 80 | 17+EA | Mem8←Mem8 OR Immed8 |
| Word | 81 | 4 | Reg16←Reg16 OR Immed16 |
| | 81 | 17+EA | Mem16←Mem16 OR Immed16 |

## OUT = Output Byte, Word

Fixed port

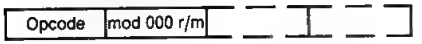

| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | E6 | 10 | Port8 ← AL |
| | E7 | 10 | Port8 ← AX |

Variable port


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Word | EE | 8 | Port16 (in DX) ← AL |
| | EF | 8 | Port16 (in DX) ← AX |

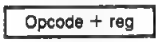
## POP = Pop a Word from the Stack

Word Memory



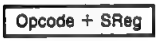

| Opcode | Clocks | Operation |
|---|---|---|
| 8F | 17+EA | Mem16 ← (SP)++ |

Word Register




| Opcode | Clocks | Operation |
|---|---|---|
| 58+reg | 8 | Reg16 ← (SP)++ |

Segment Register




| Opcode | Clocks | Operation |
|---|---|---|
| 07+SReg | 8 | SReg ← (SP)++ |



## POPF = Pop the TOS into the Flags

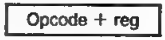

| Opcode | Clocks | Operation |
|---|---|---|
| 9D | 8 | FLAGS ← (SP)++ |

## PUSH = Push a Word onto the Stack

Memory/Reg

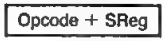

| Opcode | Clocks | Operation |
|---|---|---|
| FF | 16+EA | —(SP) ← Mem16 |

Word Register




| Opcode | Clocks | Operation |
|---|---|---|
| 50+reg | 11 | —(SP) ← Reg16 |

Segment Register



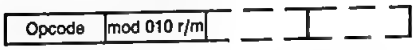

| Opcode | Clocks | Operation |
|---|---|---|
| 06+SReg | 10 | —(SP) ← SReg |

## PUSHF = Push the Flags to the Stack


| Opcode | Clocks | Operation |
|---|---|---|
| 9C | 10 | —(SP) ← FLAGS |

## RCL = Rotate Left Through Carry

Memory or Reg by 1




| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | D0 | 2 | rotate Reg 8 by 1 |
| | D0 | 15+EA | rotate Mem8 by 1 |
| Word | D1 | 2 | rotate Reg 16 by 1 |
| | D1 | 15+EA | rotate Mem16 by 1 |

Memory or Reg by count in CL

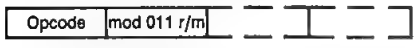

| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | D2 | 8+4/bit | rotate Reg8 by CL |
| | D2 | 20+EA+4/bit | rotate Mem8 by CL |
| Word | D3 | 8+4/bit | rotate Reg16 by CL |
| | D3 | 20+EA+4/bit | rotate Mem16 by CL |

## RCR = Rotate Right Through Carry

Memory or Reg by 1


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | D0 | 2 | rotate Reg8 by 1 |
| | D0 | 15+EA | rotate Mem8 by 1 |
| Word | D1 | 2 | rotate Reg16 by 1 |
| | D1 | 15+EA | rotate Mem16 by 1 |

Memory or Reg by count in CL




| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | D2 | 8+4/bit | rotate Reg8 by CL |
| | D2 | 20+EA+4/bit | rotate Mem8 by CL |
| Word | D3 | 8+4/bit | rotate Reg16 by CL |
| | D3 | 20+EA+4/bit | rotate Mem16 by CL |



## REP*x* = Repeat Prefix


| Opcode | Clocks | Operation | REP*x* = |
|---|---|---|---|
| F3 | 2 | repeat next instruction until CX=0 | REP |
| F3 | 2 | repeat next instruction until CX=0 or ZF=1 | REPE<br>REPZ |
| F2 | 2 | repeat next instruction until CX=0 or ZF=0 | REPNE<br>REPNZ |

## RET = Return from Subroutine

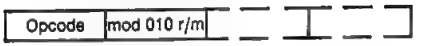

| Opcode | Clocks | Operation |
|---|---|---|
| C3 | 8 | intra-segment return |
| CB | 18 | inter-segment return |

Return and add constant to SP


| Opcode | Clocks | Operation |
|---|---|---|
| C2 | 12 | intra-segment ret and add |
| CA | 17 | inter-segment ret and add |

## ROL = Rotate Left

Memory or Reg by 1



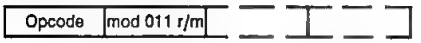

| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | D0 | 2 | rotate Reg8 by 1 |
| | D0 | 15+EA | rotate Mem8 by 1 |
| Word | D1 | 2 | rotate Reg16 by 1 |
| | D1 | 15+EA | rotate Mem16 by 1 |

Memory or Reg by count in CL


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | D2 | 8+4/bit | rotate Reg8 by CL |
| | D2 | 20+Ea+4/bit | rotate Mem8 by CL |
| Word | D3 | 8+4/bit | rotate Reg16 by CL |
| | D3 | 20+EA+4/bit | rotate Mem16 by CL |

## ROR = Rotate Right

Memory or Reg by 1




| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | D0 | 2 | rotate Reg8 by 1 |
| | D0 | 15+EA | rotate Mem8 by 1 |
| Word | D1 | 2 | rotate Reg16 by 1 |
| | D1 | 15+EA | rotate Mem16 by 1 |

Memory or Reg by count in CL


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | D2 | 8+4/bit | rotate Reg8 by CL |
| | D2 | 20+EA+4/bit | rotate Mem8 by CL |
| | D3 | 8+4/bit | rotate Reg16 by CL |
| | D3 | 20+EA+4/bit | rotate Mem16 by CL |

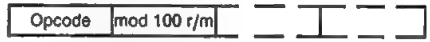


## SAHF = Store AH in Flags


| Opcode | Clocks | Operation |
|---|---|---|
| 9E | 4 | copy AH to low byte of flags word |

## SAL/SHL = Arithmetic/Logical Left Shift

Memory or Reg by 1



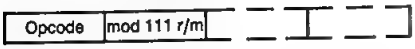

| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | D0 | 2 | shift Reg8 by 1 |
| | D0 | 15+EA | shift Mem8 by 1 |
| Word | D1 | 2 | shift Reg16 by 1 |
| | D1 | 15+EA | shift Mem16 by 1 |

Memory or Reg by count in CL


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | D2 | 8+4/bit | shift Reg8 by CL |
| | D2 | 20+EA+4/bit | shift Mem8 by CL |
| Word | D3 | 8+4/bit | shift Reg16 by CL |
| | D3 | 20+EA+4/bit | shift Mem16 by CL |

## SAR = Arithmetic Right Shift

### Memory or Reg by 1




| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | D0 | 2 | shift Reg8 by 1 |
| | D0 | 15+EA | shift Mem8 by 1 |
| Word | D1 | 2 | shift Reg16 by 1 |
| | D1 | 15+EA | shift Mem16 by 1 |

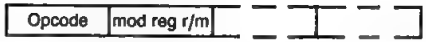
### Memory or Reg by count in CL


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | D2 | 8+4/bit | shift Reg8 by CL |
| | D2 | 20+EA+4/bit | shift Mem8 by CL |
| Word | D3 | 8+4/bit | shift Reg16 by CL |
| | D3 | 20+EA+4/bit | shift Mem16 by CL |



## SBB = Integer Subtraction with Borrow

### Memory/Reg with Reg




| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 1A | 3 | Reg8 ← Reg8 - Reg8 - CF |
| | 1A | 9+EA | Reg8 ← Reg8 - Mem8 - CF |
| | 18 | 16+EA | Mem8 ← Mem8 - Reg8 - CF |
| Word | 1B | 3 | Reg16 ← Reg16 - Reg16 - CF |
| | 1B | 9+EA | Reg16 ← Reg16 - Mem16 - CF |
| | 19 | 16+EA | Mem16 ← Mem16 - Reg16 - CF |

### Immed from AX/AL

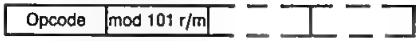

| Opcode | Clocks | Operation |
|---|---|---|
| 1C | 4 | AL ← AL - Immed8 - CF |
| 1D | 4 | AX ← AX - Immed16 - CF |

### Immed from Memory/Reg


| Opcode | Clocks | Operation |
|---|---|---|
| 80 | 4 | Reg8 ← Reg8 - Immed8 - CF |
| 80 | 17+EA | Mem8 ← Mem8 - Immed8 - CF |
| 81 | 4 | Reg16 ← Reg16 - Immed16 - CF |
| 81 | 17+EA | Mem16 ← Mem16 - Immed16 - CF |
| 83 | 4 | Reg16 ← Reg16 - Immed8 - CF |
| 83 | 17+EA | Mem16 ← Mem16 - Immed8 - CF (Immed8 is sign-extended before subtract) |

## SHR = Logical Right Shift

Memory or Reg by 1




| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | D0 | 2 | shift Reg8 by 1 |
| | D0 | 15+EA | shift Mem8 by 1 |
| Word | D1 | 2 | shift Reg16 by 1 |
| | D1 | 15+EA | shift Mem16 by 1 |

Memory or Reg by count in CL


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | D2 | 8+4/bit | shift Reg8 by CL |
| | D2 | 20+Ea+4/bit | shift Mem8 by CL |
| Word | D3 | 8+4/bit | shift Reg16 by CL |
| | D3 | 20+EA+4/bit | shift Mem16 by CL |

## STC = Set Carry Flag


| Opcode | Clocks | Operation |
|---|---|---|
| F9 | 2 | set the carry flag |

## STD = Set Direction Flags


| Opcode | Clocks | Operation |
|---|---|---|
| FD | 2 | set direction flag |



## STI = Set Interrupt Enable Flag

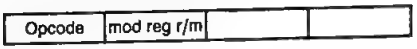

| Opcode | Clocks | Operation |
|---|---|---|
| FB | 2 | set interrupt flag |

## *String* = String Operations


| Opcode | Clocks | Operation | *String* = |
|---|---|---|---|
| A6 | 22 | flags ← (SI) - (DI) | CMPS |
| A7 | 22 | flags ← (SI) - (DI) | CMPS |
| A4 | 18 | (DI) ← (SI) | MOVS |
| A5 | 18 | (DI) ← (SI) | MOVS |
| AE | 15 | flags ← (DI) - AL | SCAS |
| AF | 15 | flags ← (DI) - AX | SCAS |
| AC | 12 | AL ← (SI) | LODS |
| AD | 12 | AX ← (SI) | LODS |
| AA | 11 | (DI) ← AL | STOS |
| AB | 11 | (DI) ← AX | STOS |

## SUB = Integer Subtraction

### Memory/Reg with Reg




| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 2A | 3 | Reg8 ← Reg8 - Reg8 |
| | 2A | 9+EA | Reg8 ← Reg8 - Mem8 |
| | 28 | 16+EA | Mem8 ← Mem8 - Reg8 |
| Word | 2B | 3 | Reg16 ← Reg16 - Reg16 |
| | 2B | 9+EA | Reg16 ← Reg16 - Mem16 |
| | 29 | 16+EA | Mem16 ← Mem16 - Reg16 |

### Immed to AX/AL


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 2C | 4 | AL ← AL - Immed8 |
| Word | 2D | 4 | AX ← AX - Immed16 |

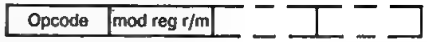
### Immed to Memory/Reg


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 80 | 4 | Reg8 ← Reg8 - Immed8 |
| | 80 | 17+EA | Mem8 ← Mem8 - Immed8 |
| Word | 81 | 4 | Reg16 ← Reg16 - Immed16 |
| | 81 | 17+EA | Mem16 ← Mem16 - Immed16 |
| | 83 | 4 | Reg16 ← Reg16 - Immed8 |
| | 83 | 17+EA | Mem16 ← Mem16 - Immed8 |



## TEST = Logical Compare

### Memory/Reg with Reg




| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 84 | 3 | flags ← Reg8 AND Reg8 |
| | 84 | 9+EA | flags ← Reg8 AND Mem8 |
| Word | 85 | 3 | flags ← Reg16 AND Reg16 |
| | 85 | 9+EA | flags ← Reg16 AND Mem16 |

### Immed to AX/AL


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | A8 | 4 | flags ← AL AND Immed8 |
| Word | A9 | 4 | flags ← AX AND Immed16 |

### Immed to Memory/Reg

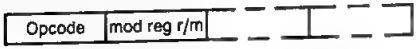

| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | F6 | 5 | flags ← Reg8 AND Immed8 |
| | F6 | 11+EA | flags ← Mem8 AND Immed8 |
| Word | F7 | 5 | flags ← Reg16 AND Immed16 |
| | F7 | 11+EA | flags ← Mem16 AND Immed16 |

## WAIT = Wait While TEST Pin Not Asserted


| Opcode | Clocks | Operation |
|---|---|---|
| 9B | 3+5n | none |

## XCHG = Exchange Memory/Register with Register

### Memory/Reg with Reg




| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 86 | 4 | Reg8 ⇄ Reg8 |
| | 86 | 17+EA | Mem8 ⇄ Mem8 |
| Word | 87 | 4 | Reg16 ⇄ Reg16 |
| | 87 | 17+EA | Mem16 ⇄ Mem16 |

### Word Register with AX


| Opcode | Clocks | Operation |
|---|---|---|
| 90+Reg | 3 | AX ⇄ Reg16 |

## XLAT XLATB = Table Look-up Translation


| Opcode | Clocks | Operation |
|---|---|---|
| D7 | 11 | replace AL with table entry |



## XOR = Logical Exclusive OR

### Memory/Reg with Reg


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 32 | 3 | Reg8 ← Reg8 XOR Reg8 |
| | 32 | 9+EA | Reg8 ← Reg8 XOR Mem8 |
| | 30 | 16+EA | Mem8 ← Mem8 XOR Reg8 |
| Word | 33 | 3 | Reg16 ← Reg16 XOR Reg16 |
| | 33 | 9+EA | Reg16 ← Reg16 XOR Mem16 |
| | 31 | 16+EA | Mem16 ← Mem16 XOR Reg16 |

### Immed to AX/AL


| Opcode | Clocks | Operation |
|---|---|---|
| 34 | 4 | AL ← AL XOR Immed8 |
| 35 | 4 | AX ← AX XOR Immed16 |

### Immed to Memory/Reg


| | Opcode | Clocks | Operation |
|---|---|---|---|
| Byte | 80 | 4 | Reg8 ← Reg8 XOR Immed8 |
| | 80 | 17+EA | Mem8 ← Mem8 XOR Immed8 |
| Word | 81 | 4 | Reg16 ← Reg16 XOR Immed16 |
| | 81 | 17+EA | Mem16 ← Mem16 XOR Immed16 |

## 186 INSTRUCTIONS

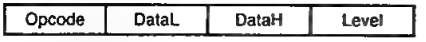
### Notes for iAPX 186 Instructions

These instructions can be used only if the MOD186 control is specified. When MOD186 is specified, clocks for all instructions are as stated under "Clocks for MOD186 Operation."

### BOUND = Check Array Against Bounds


| Opcode | Operation |
|---|---|
| 62 | if Reg16<Mem16 at EA, or Reg16>Mem16 at EA+2 then INTERRUPT 5 |

### ENTER = High Level Procedure Entry




| Opcode | Operation |
|---|---|
| C8 | build new stack frame |

### IMUL = Signed Multiplication

Mem/Reg* Immediate to Reg


| Opcode | Operation |
|---|---|
| 6B | Reg 16 ← Reg 16 * Immed 8 |
| 6B | Reg 16 ← Reg 16 * Immed 8 |
| 6B | Reg 16 ← Mem 16 * Immed 8 |
| 69 | Reg 16 ← Reg 16 * Immed 16 |
| 69 | Reg 16 ← Reg 16 * Immed 16 |
| 69 | Reg 16 ← Mem 16 * Immed 16 |



### LEAVE = High Level Procedure Exit


| Opcode | Operation |
|---|---|
| C9 | release current stack frame and return to prior frame. |

### POPA = Pop All Registers


| Opcode | Operation |
|---|---|
| 61 | restore registers from stack |

### PUSH = Push a Word onto the Stack

Word Immediate


| Opcode | Operation |
|---|---|
| 6A | —(SP) ← Immed8 (sign extended) |
| 68 | —(SP) ← Immed16 |

### PUSHA = Push All Registers


| Opcode | Operation |
|---|---|
| 60 | save registers on the stack |

## RCL = Rotate Left Through Carry

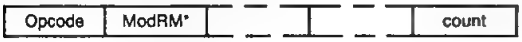
Mem or Reg by Immed8


*—(Reg field = 011)

| Opcode | Operation |
|---|---|
| C0 | rotate Reg8 by Immed8 |
| C0 | rotate Mem8 by Immed8 |
| C1 | rotate Reg16 by Immed8 |
| C1 | rotate Mem16 by Immed8 |

## RCR = Rotate Right Through Carry

Mem or Reg by Immed8




*—(Reg field = 011)

| Opcode | Operation |
|---|---|
| C0 | rotate Reg8 by Immed8 |
| C0 | rotate Mem8 by Immed8 |
| C1 | rotate Reg16 by Immed8 |
| C1 | rotate Mem16 by Immed8 |

## ROL = Rotate Left

Mem or Reg by Immed8


*—(Reg field = 000)

| Opcode | Operation |
|---|---|
| C0 | rotate Reg8 by Immed8 |
| C0 | rotate Mem8 by Immed8 |
| C1 | rotate Reg16 by Immed8 |
| C1 | rotate Mem16 by Immed8 |



## ROR = Rotate Right

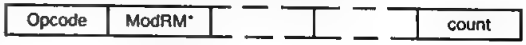
Mem or Reg by Immed8


*—(Reg field = 001)

| Opcode | Operation |
|---|---|
| C0 | rotate Reg8 by Immed8 |
| C0 | rotate Mem8 by Immed8 |
| C1 | rotate Reg16 by Immed8 |
| C1 | rotate Mem16 by Immed8 |

## SAL/SHL = Arithmetic/Logical Left Shift

Mem or Reg by immediate count




*—(Reg field = 100)

| Opcode | Operation |
|---|---|
| C0 | rotate Reg8 by Immed8 |
| C0 | rotate Mem8 by Immed8 |
| C1 | rotate Reg16 by Immed8 |
| C1 | rotate Mem16 by Immed8 |

## SAR = Arithmetic Right Shift

Mem or Reg by Immed8


*—(Reg field = 111)

| Opcode | Operation |
|---|---|
| C0 | rotate Reg8 by Immed8 |
| C0 | rotate Mem8 by Immed8 |
| C1 | rotate Reg16 by Immed8 |
| C1 | rotate Mem16 by Immed8 |

## SHR = Logical Right Shift

Mem or Reg by Immed8


*—(Reg field = 101)

| Opcode | Operation |
|---|---|
| C0 | rotate Reg8 by Immed8 |
| C0 | rotate Mem8 by Immed8 |
| C1 | rotate Reg16 by Immed8 |
| C1 | rotate Mem16 by Immed8 |

## *String* = String Operations (INS/OUTS)

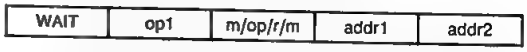

| Opcode | Clocks | Operation |
|---|---|---|
| 6E | INS | (DI) ← port(DX) |
| 6F | INS | (DI) ← port(DX:DX+1) |
| 6C | OUTS | port(DX) ← (SI) |
| 6D | OUTS | port(DX:DX+1) ← (SI) |



# 8087 INSTRUCTIONS

## Notes for 8087 Instructions

The individual instruction descriptions are shown by a format box such as the following:




These are the byte-wise representations of the object code generated by the assembler and are interpreted as follows:

- WAIT is an 8086 wait instruction, NOP or emulator instruction.
- op1 is the opcode, possibly taking two bytes.
- m/op/r/m byte (middle 3-bits is part of the opcode).
- addr1 and addr2 are offsets of either 8 or 16 bits.

For integer functions, m = 0 for short-integer memory operand; 1 for word-integer memory operand.
For real functions, m = 0 for short-real memory operand; 1 for longreal memory operand.
i = stack element index.

If mod = 00 then DISP = 0 , disp-lo and disp-hi are absent.
If mod = 01 then DISP = disp-lo sign-extended to 16 bits, disp-hi is absent.
If mod = 10 then DISP = disp-hi; disp-lo.
If mod = 11 then r/m is treated as an ST(i) field.

If r/m = 000 then EA = (BX)+(SI)+DISP
If r/m = 001 then EA = (BX)+(DI)+DISP
If r/m = 010 then EA = (BP)+(SI)+DISP
If r/m = 011 then EA = (BP)+(DI)+DISP
If r/m = 100 then EA = (SI)+DISP
If r/m = 101 then EA = (DI)+DISP
If r/m = 110 then EA (BP)+DISP*
If r/m = 111 then EA = (BX)+DISP
*Except if mod = 000 and r/m = 110 then EA = disp-hi; disp-lo.

ST(0) = Current stack top
ST(i) = ith register below stack top
d = Destination
0 — Destination is ST(0)
1 — Destination is ST(i)
P = Pop
0 — No pop
1 — Pop ST(0)
R = Reverse
0 — Destination (op) source
1 — Source (op) destination

For FSQRT: $-0 \leq ST(0) < +\infty$
For FSCALE: $-2^{15} \leq ST(1) < +2^{15}$ and ST(1) integer
For F2XM1: $0 \leq ST(0) \leq 2^{-1}$
For FYL2X: $0 \leq ST(0) < \infty$
$-\infty < ST(1) < +\infty$
For FYL2XP1: $0 < |ST(0)| < (2-\sqrt{2})/2$
$-\infty \leq ST(1) < \infty$
For FPTAN: $0 \leq ST(0) < \pi/4$
For FPATAN: $0 \leq ST(0) < ST(1) < +\infty$

## F2XMI = Compute $2^x - 1$

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 F0 | CD 19 F0 | 500<br>310-630 | ST ← $2^{ST}-1$ |

## FABS = Absolute Value

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 E1 | CD 19 E1 | 14<br>10-17 | ST ← \|ST\| |



## FADD = Add Real

Stack top + Stack element

| WAIT | op1 | op2 + i |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 C0+i | CD 18 C0+i | 85<br>70-100 | ST ← ST + ST(i) |
| 9B DC C0+i | CD 1C C0+i | 85<br>70-100 | ST(i) ← ST + ST(i) |

Stack top + memory operand

| WAIT | op1 | mod 000 r/m | addr1 | addr2 |
|---|---|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 m0rm | CD 18 m0rm | 105+EA<br>(90-120)+EA | ST ← ST + mem-op (short-real) |
| 9B DC m0rm | CD 1C m0rm | 110+EA<br>(95-125)+EA | ST ← ST + mem-op (long-real) |

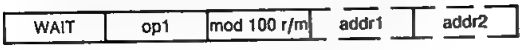
## FADDP = Add Real and Pop

Stack top + Stack Element

| WAIT | op1 | op2 + i |
|---|---|---|

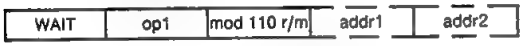
| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DE C1 | CD 1E C1 | 90<br>75-105 | ST(1) ← ST + ST(1)<br>pop stack |
| 9B DE C0+i | CD 1E C0+i | 90<br>75-105 | ST(i) ← ST + ST(i)<br>pop stack |

## FBLD = Packed Decimal (BCD) Load



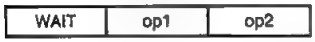

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DF m4rm | CD 1F m4rm | 300+EA<br>(290-310)+EA | push stack<br>ST ← mem-op |

## FBSTP = Packed Decimal (BCD) Store and Pop




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DF m6rm | CD 1F m6rm | 530+EA<br>(520-540)+EA | mem-op ← ST<br>pop stack |

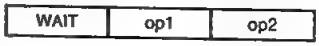
## FCHS = Change Sign




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 E0 | CD 19 E0 | 15<br>10-17 | ST ← —ST |



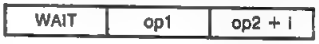
## FCLEX<br>FNCLEX = Clear Exceptions




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DB E2 | CD 1B E2 | 5<br>2-8 | clear 8087 exceptions |
| 90 DB E2 | CD 1B E2 | 5<br>2-8 | clear 8087 exceptions<br>(no wait) |

## FCOM = Compare Real

Compare Stack top and Stack element



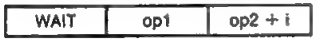

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 D1 | CD 18 D1 | 45<br>40-50 | ST — ST(1) |
| 9B D8 D0+i | CD 18 D0+i | 45<br>40-50 | ST — ST(i) |

Compare Stack top and memory operands


| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 m2rm | CD 18 m2rm | 65+EA<br>(60-70)+EA | ST — memop<br>(short-real) |
| 9B DC m2rm | CD 1C m2rm | 70+EA<br>(65-75)+EA | ST — memop<br>(long-real) |

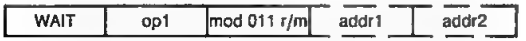
## FCOMP = Compare Real and Pop

Compare Stack top and Stack element and pop



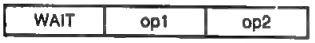

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 D9 | CD 18 D9 | 47<br>42-52 | ST — ST(1)<br>pop stack |
| 9B D8 D8+i | CD 18 D8+i | 47<br>42-52 | ST — ST(i)<br>pop stack |

Compare Stack top and memory operand and pop




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 m3rm | CD 18 m3rm | 68+EA<br>(63-73)+EA | ST — mem-op<br>pop stack<br>(short-real) |
| 9B DC m3rm | CD 1C m3rm | 72+EA<br>(67-77)+EA | ST — mem-op<br>pop stack<br>(long-real) |

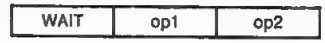
## FCOMPP = Compare Real and Pop Twice




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DE D9 | CD 1E D9 | 50<br>45-55 | ST — ST(1)<br>pop stack<br>pop stack |

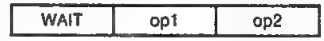


## FDECSTP = Decrement Stack Pointer




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 F6 | CD 19 F6 | 9<br>6-12 | stack pointer ←<br>stack pointer 1 |

## FDISI<br>FNDISI = Disable Interrupts




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DB E1 | CD 1B E1 | 5<br>2-8 | Set 8087 interrupt mask |
| 90 DB E1 | CD 1B E1 | 5<br>2-8 | Set 8087 interrupt mask (no wait) |

## FDIV = Divide Real

Stack top and Stack element

| WAIT | op1 | op2 + i |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 F0+i | CD 18 F0+i | 198 193-203 | ST ← ST/ST(i) |
| 9B DC F8+i | CD 1C F8+i | 198 193-203 | ST(i) ← ST(i)/ST |

Stack top and memory operand

| WAIT | op1 | mod 110 r/m | addr1 | addr2 |
|---|---|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 m6rm | CD 18 m6rm | 220+EA (215-225)+EA | ST ← ST/mem-op (short-real) |
| 9B DC m6rm | CD 1C m6rm | 225+EA (220-230)+EA | ST ← ST/mem-op (long-real) |

## FDIVP = Divide Real and Pop

| WAIT | op1 | op2 + i |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DE F9 | CD 1E F9 | 202 197-207 | ST(1) ← ST(1)/ST pop stack |
| 9B DE F8+i | CD 1E F8+i | 202 197-207 | ST(i) ← ST(i)/ST pop stack |



## FDIVR = Divide Real Reversed

Stack top and Stack element

| WAIT | op1 | op2 + i |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 F8+i | CD 18 F8+i | 199 194-204 | ST ← ST(i)/ST |
| 9B DC F0+i | CD 1C F0+i | 199 194-204 | ST(i) ← ST/ST(i) |

Stack top and memory operand

| WAIT | op1 | mod 111 r/m | addr1 | addr2 |
|---|---|---|---|---|

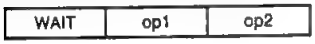
| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 m7rm | CD 18 m7rm | 221+EA (216-226)+EA | ST ← mem-op/ST (short-real) |
| 9B DC m7rm | CD 1C m7rm | 226+EA (221-231)+EA | ST ← mem-op/ST (long-real) |

## FDIVRP = Divide Real Reversed and Pop

| WAIT | op1 | op2 + i |
|---|---|---|

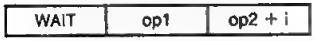
| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DE F1 | CD 1E F1 | 203 198-208 | ST(1) ← ST/ST(1) pop stack |
| 9B DE F0+i | CD 1E F0+i | 203 198-208 | ST(i) ← ST/ST(i) |

## FENI
## FNENI = Enable Interrupts




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DB E0 | CD 1B E0 | 5<br>2-8 | clear 8087 interrupt mask |
| 90 DB E0 | CD 1B E0 | 5<br>2-8 | clear 8087 interrupt mask (no wait) |

## FFREE = Free Register



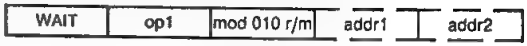

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DD C0+i | CD 1D C0+i | 11<br>9-16 | TAG(i) masked empty |

## FIADD = Integer Add


| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DA m0rm | CD 1A m0rm | 125+EA<br>(108-143)+EA | ST ← ST + mem-op (short integer) |
| 9B DE m0rm | CD 1E m0rm | 120+EA<br>(102-137)+EA | ST ← ST + mem-op (word integer) |

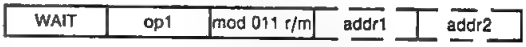


## FICOM = Integer Compare




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DA m2rm | CD 1A m2rm | 85+EA<br>(78-91)+EA | ST — mem-op (short integer) |
| t9B DE m2rm | CD 1E m2rm | 80+EA<br>(72-86)+EA | ST — mem-op (word integer) |

## FICOMP = Integer Compare and Pop

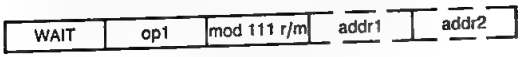



| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DA m3rm | CD 1A m3rm | 87+EA<br>(80-93)+EA | ST — mem-op pop stack (short integer) |
| 9B DE m3rm | CD 1E m3rm | 82+EA<br>(74-88)+EA | ST — mem-op pop stack (word integer) |

## FIDIV = Integer Divide


| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DA m6rm | CD 1A m6rm | 236+EA<br>(230-243)+EA | ST ← ST/mem-op (short integer) |
| 9B DE m6rm | CD 1E m6rm | 230+EA<br>(224-238)+EA | ST ← ST/mem-op (word integer) |

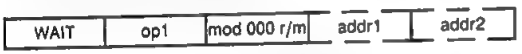
## FIDIVR = Integer Divide Reversed




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DA m7rm | CD 1A m7rm | 237+EA<br>(231-245)+EA | ST←mem-op/ST<br>(short integer) |
| 9B DE m7rm | CD 1E m7rm | 230+EA<br>(225-239)+EA | ST←mem-op/ST<br>(word integer) |

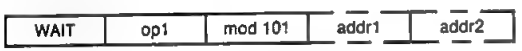
## FILD = Integer Load

### Word Integer or Short Integer




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DB m0rm | CD 1B m0rm | 56+EA<br>(52-60)+EA | push stack<br>ST←mem-op<br>(short integer) |
| 9B DF m0rm | CD 1F m0rm | 50+EA<br>(46-54)+EA | push stack<br>ST←mem-op<br>(word integer) |

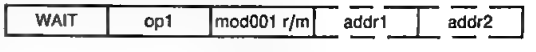
### Long Integer




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DF m5rm | CD 1F m5rm | 64+EA<br>(60-68)+EA | push stack<br>ST←mem-op<br>(long integer) |

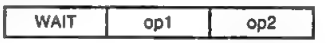


## FIMUL = Integer Multiply




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DA m1rm | CD 1A m1rm | 136 + EA<br>(130-144)+EA | ST←ST * mem-op<br>(short integer) |
| 9B DE m1m | CD 1E m1m | 130 + EA<br>(124-138)+EA | ST←ST * mem-op<br>(word integer) |

## FINCSTP = Increment Stack Pointer

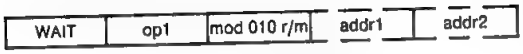



| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 F7 | CD 19 F7 | 9<br>6-12 | stack pointer ←<br>stack pointer + 1 |

## FINIT<br>FNINIT = Initialize Processor


| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DB E3 | CD 1B E3 | 5<br>2-8 | initialize 8087 |
| 90 DB E3 | CD 1B E3 | 5<br>2-8 | initialize 8087<br>(no wait) |

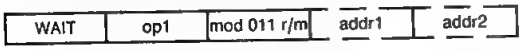
## FIST = Integer Store




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DB m2rm | CD 1B m2rm | 88+EA (82-92)+EA | mem-op→ST (short integer) |
| 9B DF m2rm | CD 1F m2rm | 86+EA (80-90)+EA | mem-op→ST (word integer) |

## FISTP = Integer Store and Pop

### Short Integer or Word Integer




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DB m3rm | CD 1B m3rm | 90+EA (84-94)+EA | mem-op→ST pop stack (short integer) |
| 9B DF m3rm | CD 1F m3rm | 88+EA (82-92)+EA | mem-op→ST pop stack (word integer) |

### Long Integer


| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DF m7rm | CD 1F m7rm | 100+EA (94-105)+EA | mem-op→ST pop stack (long integer) |



## FISUB = Integer Subtract


| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DA m4rm | CD 1A m4rm | 125+EA (108-143)+EA | ST→ST — mem-op (short integer) |
| 9B DE m4rm | CD 1E m4rm | 120+EA (102-137)+EA | ST→ST — mem-op (word integer) |

## FISUBR = Integer Subtract Reversed


| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DA m5rm | CD 1A m5rm | 125+EA (109-144)+EA | ST→mem-op — ST (short integer) |
| 9B DE m5rm | CD 1E m5rm | 120+EA (103-139)+EA | ST→mem-op — ST (word integer) |

## FLD = Load Real

Stack element to Stack top

| WAIT | op1 | op2 + i |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 C0+i | CD 19 C0+i | 20<br>17-22 | T, ← ST(i)<br>push stack<br>ST ← T, |

Memory operand to Stack top
Short Integer or Long Integer

| WAIT | op1 | mod 000 r/m | addr1 | addr2 |
|---|---|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 m0rm | CD 19 m0rm | 43+EA<br>(38-56)+EA | push stack<br>ST ← mem-op<br>(short integer) |
| 9B DD m0rm | CD 1D m0rm | 46+EA<br>(40-60)+EA | push stack<br>ST ← mem-op<br>(long integer) |

Temp Real

| WAIT | op1 | mod 101 | addr1 | addr2 |
|---|---|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DB m5rm | CD 1B m5rm | 57+EA<br>(53-65)+EA | push stack<br>ST ← mem-op<br>(temp real) |



## FLD1 = Load + 1.0

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 E8 | CD 19 E8 | 18<br>15-21 | push stack<br>ST ← 1.0 |

## FLDCW = Load Control Word

| WAIT | op1 | mod 101 r/m | addr1 | addr2 |
|---|---|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 m5rm | CD 19 m5rm | 10+EA<br>(7-14)+EA | processor control<br>word ← mem-op |

## FLDENV = Load Environment

| WAIT | op1 | mod 100 r/m | addr1 | addr2 |
|---|---|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 m4rm | CD 19 m4rm | 40+EA<br>(35-45)+EA | 8087 environment ← mem-op |

## FLDL2E = Load $Log_2e$

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 EA | CD 19 EA | 18<br>15-21 | push stack<br>ST ← $log_2e$ |

## FLDL2T = Load $Log_2 10$

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 E9 | CD 19 E9 | 19<br>16-22 | push stack<br>ST ← $log_2 10$ |

## FLDLG2 = Load $Log_{10} 2$

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 EC | CD 19 EC | 21<br>18-24 | push stack<br>ST ← $log_{10} 2$ |

## FLDPI = Load $\pi$

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 EB | CD 19 EB | 19<br>16-22 | push stack<br>ST ← $\pi$ |

## FLDZ = Load + 0.0

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 EE | CD 19 EE | 14<br>11-17 | push stack<br>ST ← 0.0 |



## FMUL = Multiply Real

### Stack top and Stack element

| WAIT | op1 | op2 + i |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 C8+i | CD 18 C8+i | 138<br>130-145 | ST ← ST * ST(i) |
| 9B DC C8+i | CD 1C C8+i | 138<br>130-145 | ST(i) ← ST(i) — ST |

### Stack top and memory operand

| WAIT | op1 | mod 001 r/m | addr1 | addr2 |
|---|---|---|---|---|

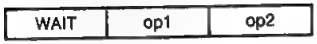
| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 m1rm | CD 18 m1rm | 118+EA<br>(110-125)+EA | ST ← ST * mem-op<br>(short real) |
| 9B DC m1rm | CD 1C m1rm | 161+EA<br>(154-168)+EA | ST ← ST * mem-op<br>(long real) |

## FMULP = Multiply Real and Pop

| WAIT | op1 | op2 + i |
|---|---|---|

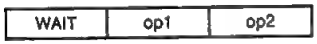
| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DE C9 +i | CD 1E C9+i | 142<br>134-148 | ST(i) ← ST(i) * ST<br>pop stack |

## FNOP = No Operation



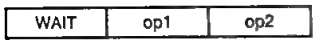

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 D0 | CD 19 D0 | 13<br>10-16 | ST ← ST |

## FPATAN = Partial Arctangent



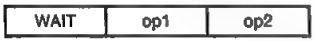

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 F3 | CD 19 F3 | 650<br>250-800 | $T_1$ ← arctan (ST(1)/ST)<br>pop stack<br>ST ← $T_1$ |

## FPREM = Partial Remainder




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 F8 | CD 19 F8 | 125<br>15-190 | ST ← REPEAT<br>(ST — ST(1)) |

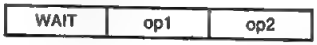
## FPTAN = Partial Tangent




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 F2 | CD 19 F2 | 450<br>30-540 | Y/X ← TAN (ST)<br>ST ← Y<br>push stack<br>ST ← X |



## FRNDINT = Round to Integer

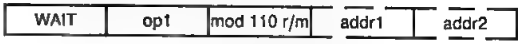



| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 FC | CD 19 FC | 45<br>16-50 | ST ← nearest integer (ST) |

## FRSTOR = Restore Saved State


| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DD m4rm | CD 1D m4rm | 202+EA<br>(197-207)+EA | 8087 state ← mem-op |

## FSAVE<br>FNSAVE = Save State




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DD m6rm | CD 1D m6rm | 202+EA<br>(197-207)+EA | mem-op ← 8087 state |
| 90 DD m6rm | CD 1D m6rm | 202+EA<br>(197-207)+EA | mem-op ← 8087 state<br>(no wait) |

## FSCALE = Scale

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 FD | CD 19 FD | 35<br>32-38 | $ST \leftarrow ST * 2^{[ST]}$ |

## FSQRT = Square Root

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 FA | CD 19 FA | 183<br>180-186 | $ST \leftarrow \sqrt{ST}$ |



## FST = Store Real

### Stack top to Stack element

| WAIT | op1 | op2 + i |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DD D0+i | CD 1D D0+i | 18<br>15-22 | ST(i) ← ST |

### Stack top to memory operand

| WAIT | op1 | mod 010 r/m | addr1 | addr2 |
|---|---|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 m2rm | CD 19 m2rm | 87+EA<br>(84-90)+EA | mem-op ← ST<br>(short-real) |
| 9B D0 m2rm | CD 1D m2rm | 100+EA<br>(96-104)+EA | mem-op ← ST<br>(long-real) |

## FSTCW<br>FNSTCW = Store Control Word

| WAIT | op1 | mod 111 r/m | addr1 | addr2 |
|---|---|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 m7rm | CD 19 m7rm | 15+EA<br>(12-18)+EA | mem-op ← processor control word |
| 90 D9 m7rm | CD 19 m7rm | 15+EA<br>(12-18)+EA | mem-op ← processor control word<br>(no wait) |

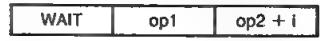
## FSTENV
## FNSTENV = Store Environment


| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 m6rm | CD 19 m6rm | 45+EA (40-50)+EA | mem-op ← 8087 environment |
| 90 D9 r6rm | CD 19 m6rm | 45+EA (40-50)+EA | mem-op ← 8087 environment (no wait) |



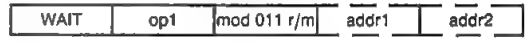
## FSTP = Store Real and Pop

### Stack top to Stack element




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DD D8+I | CD 1D D8+I | 20<br>17-24 | ST(I) ← ST<br>pop stack |

### Stack top to memory operand




### Long Real or Short Real

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 m3rm | CD 19 m3rm | 89+EA (86-92)+EA | mem-op ← ST<br>pop stack<br>(short-real) |
| 9B DB m3rm | CD 1B m3rm | 102+EA (98-106)+EA | mem-op ← ST<br>pop stack<br>(long-real) |

### Temp Real

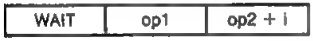

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DD m7rm | CD 1D m7rm | 55+EA (52-58)+EA | mem-op ← ST<br>pop stack<br>(temp-real) |

## FSTSW
## FNSTSW = Store Status Word


| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DD m7rm | CD 1D m7rm | 15+EA (12-18)+EA | mem-op→8087 status word |
| 90 DD m7rm | CD 1D m7rm | 15+EA (12-18)+EA | mem-op→8087 status word (no wait) |

## FSUB = Subtract Real

Stack top and Stack element



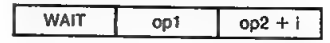

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 E0+i | CD 18 E0+i | 85 70-100 | ST←ST — ST(i) |
| 9B DC E8+i | CD 1C E8+i | 85 70-100 | ST(i)←ST(i) — ST |

Stack top and memory operand


| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 m4rm | CD 18 m4rm | 105+EA (90-120)+EA | ST←ST — mem-op (short-real) |
| 9B DC m4rm | CD 1C m4rm | 110+EA (95-125)+EA | ST←ST — mem-op (long-real) |



## FSUBP = Subtract Real and Pop




| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DE E9 | CD 1E E9 | 90 75-105 | ST(1)←ST(1) — ST pop stack |
| 9B DE E8+i | CD 1E E8+i | 90 75-105 | ST(i)←ST(i) — ST pop stack |

## FSUBR = Subtract Real Reversed

Stack top and Stack element


| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 E8+i | CD D8 E8+i | 87 70-100 | ST←ST(i) — ST |
| 9B DC E0+i | CD 1C E0+i | 87 70-100 | ST(i)←ST — ST(i) |

Stack top and memory operand


| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D8 m5rm | CD 18 m5rm | 105+EA (90-120)+EA | ST←mem-op — ST (short-real) |
| 9B DC m5rm | CD 1C m5rm | 110+EA (95-125)+EA | ST←mem-op — ST (long-real) |

## FSUBRP = Subtract Real Reversed and Pop

| WAIT | op1 | op2 + i |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B DE E1 | CD 1E E1 | 90<br>75-105 | ST(1)←ST — ST(1)<br>pop stack |
| 9B DE E0+i | CD 1E E0+i | 90<br>75-105 | ST(i)←ST — ST(i)<br>pop stack |

## FTST = Test Stack Top Against + 0.0

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 E4 | CD 19 E4 | 42<br>38-48 | ST←ST — 0.0 |

## FWAIT = (CPU) Wait While 8087 Is Busy

| WAIT |
|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B | 90 | 3+5n<br>3+5n | 8086 wait instruction |



## FXAM = Examine Stack Top

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 E5 | CD 19 E5 | 17<br>12-23 | set condition code |

## FXCH = Exchange Registers

| WAIT | op1 | op2 + i |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 C8 | CD 19 C8 | 12<br>10-15 | $T_1 \leftarrow ST(1)$<br>ST(1)←ST<br>ST←$T_1$ |
| 9B D9 C8+i | CD 19 C8+i | 12<br>10-15 | $T_1 \leftarrow ST(i)$<br>ST(i)←ST<br>ST←$T_1$ |

## FXTRACT = Extract Exponent and Significand

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 F4 | CD 19 F4 | 50<br>27-55 | $T_1 \leftarrow$ exponent (ST)<br>$T_2 \leftarrow$ significand (ST)<br>ST←$T_1$<br>push stack<br>ST←$T_2$ |

## FYL2X = Compute Y * $Log_2$ X

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 F1 | CD 19 F1 | 950<br>900-1100 | $T_1 \leftarrow ST(1) * \log_2(ST)$<br>pop stack<br>$ST \leftarrow T_1$ |

## FYL2XP1 = Compute Y * $Log_2$ (X+1)

| WAIT | op1 | op2 |
|---|---|---|

| 8087 Encoding | Emulator Encoding | Execution Clocks Typical Range | Operation |
|---|---|---|---|
| 9B D9 F9 | CD 19 F9 | 850<br>700-1000 | $T_1 \leftarrow ST + 1$<br>$T_2 \leftarrow ST(1) * \log_2 T_1$<br>pop stack<br>$ST \leftarrow T_2$ |



## Assembler Controls Summary

*Default control shown in italics*

**PRIMARY CONTROLS**

| Control | Effect |
|---|---|
| DATE(d) | System Date |
| DEBUG/*NODEBUG*<br>DA<br>DB/*NODB* | DEBUG puts local symbols information into object file for debugging. NODEBUG suppresses loading of local symbols information. |
| ERRORPRINT/*NOERRORPRINT*<br>EP/*NOEP* | ERRORPRINT creates a file containing a listing of source line errors. NOERRORPRINT suppresses creation of that file. |
| *MACRO*/NOMACRO<br>*MR*/NOMR | MACRO specifies that macro processor language will be recognized in source files. NOMACRO specifies nonrecognnition of macros. They are scanned as is normal assembly language. |
| MOD186/*8086 mode*<br>M1 | MOD186 specifies that the iAPX 186 instruction set be recognized. The default is 8086 instructions only. |
| *OBJECT*/NOOBJECT<br>*OJ*/NOOJ | OBJECT specifies the creation of tan object module in the file specified. NOOBJECT specifies that an object module is not to be created. |
| PAGELENGTH(n)<br>PL(n) | Specifies number (n) of printed lines per page in print file. Minimum pagelength is 20. Default is 60 lines per page. |
| PAGEWIDTH (n)<br>PW (n) | Specifies the number (n) of characters, or columns, per line in the print and the errorprint files. Minimum is 60, maximum is 255. Default is 120. |
| *PAGING*/NOPAGING<br>*PI*/NOPI | PAGING specifies that print file is to be formatted into pages with header at top of each page. NOPAGING specifies no formatting into pages. |

| | |
|---|---|
| *PRINT*/NOPRINT<br>*PR*/NOPR | PRINT specifies that a source listing will be created during assembly. If no filename is specified, the source listing is written to the source file with the extension .LST appended. NOPRINT specifies that no source listing will be created. |
| SYMBOLS/*NOSYMBOLS*<br>SB/*NOSB* | SYMBOLS specifies that a symbol listing table will be appended to the source listing in print file. NOSYMBOLS suppresses symbol table listing. |
| TYPE/*NOTYPE*<br>TY/*NOTY* | TYPE specifies that type information be put into the object module. NOTYPE specifies that no type information be put into the object module. |
| WORKFILES<br>WF | WORKFILES specifies the devices or directories used for storage of assembler-created temporary workfiles. |
| XREF/*NOXREF*<br>XR/*NOXR* | XREF specifies that a symbol table, including line numbers, be appended to the source listing in print file. NOXREF specifies that no cross-reference line numbers are to be included. |

**GENERAL CONTROLS**

| | |
|---|---|
| EJECT<br>EJ | Next line of source listing to be placed on new page. |
| GEN/*GENONLY*/NOGEN<br>GE/*GO*/NOGE | Specify mode of listing assembler source text, macro calls and macro text in print file. GEN produces a listing that includes all source text, macro calls and expansion of each macro. GENONLY produces a listing that includes only source file non-macro text, and final result text for each macro called. NOGEN produces a listing that includes only the source file text. |
| INCLUDE<br>IC | Causes subsequent source lines to be input from specified file. |



| | |
|---|---|
| *LIST*/NOLIST<br>*LI*/NOLI | LIST specifies that listing of source program in print file is to resume with next source line read. NOLIST specifies that listing of source program in print file, beginning with next source line, is to be suppressed. |
| SAVE/RESTORE<br>SA/RS | SAVE specifies that current setting of general controls be saved on a stack. RESTORE specifies that general controls be set to values stored on stack. |
| TITLE<br>TT | Specifies the character string to appear on page header. Default title is module name specified in assembler NAME directive. |

## ASM86 Invocation under DOS

The following are instructions for invoking ASM86 on an IBM PC AT or IBM PC XT. Version 3.0 or greater of DOS is required. When the DOS prompt is displayed, you can invoke ASM86 as follows:

C>ASM86 *sourcepath* [*controls*] <cr>

where

| | |
|---|---|
| ASM86 | is the name of the ASM86 Macro Assembler. |
| *sourcepath* | is the pathname of the file containing the assembly language source module. |
| *controls* | is an optional sequence of assembler controls (and their parameters, if any) as defined in Chapter 3 of the *ASM86 Macro Assembler Operating Instructions for DOS Systems.* |

DOS places a 128 character limit on the length of each line in the invocation sequence. To continue an invocation line, enter an ampersand (&) at the end of the line and press a carriage return. Two right angle brackets (>>) will appear on the next line. This is a prompt for you to continue the invocation line.

## Assembler Directives

Symbol Definition:

EQU
LABEL
PURGE

Memory Reservation and Data Definition:

DB
DW
DD
DQ
DT
RECORD

Location Counter and Segmentation Control:

SEGMENT/ENDS
ORG
GROUP
ASSUME
PROC/ENDP
CODEMACRO/ENDM

Program Linkage:

NAME
PUBLIC
EXTRN
END

## Processor Reset Register Initialization

Flags = 0000H (to disable interrupts and single-stepping)

CS = FFFFH
IP = 0000H (to begin execution at FFFF0H)



DS = 0000H
SS = 0000H
ES = 0000H

No other registers are acted upon during reset.

## MCS®-86 Reserved Locations

### Reserved Memory Locations

Intel Corporation reserves the use of memory location FFFF0H through FFFFFH (with the exception of FFFF0H - FFFF5H for JMP instr.) for Intel hardware and software products. If you use these locations for some other purpose, you may preclude compatibility of your system with certain of these products.

### Reserved Input/Output Locations

Intel Corporation reserves the use of input/output locations F8H through FFH for Intel hardware and software products. Users who wish to maintain compatibility with present and future Intel products should not use these locations.

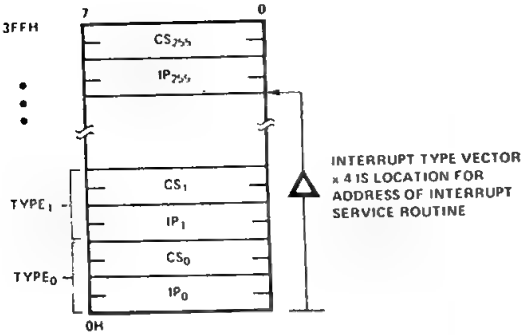
### Reserved Interrupt Locations

Intel Corporation reserves the use of interrupts 0-31 (locations 00H through 7FH) for Intel hardware and software products. Users who wish to maintain compatibility with present and future Intel products should not use these locations.

Interrupts 0 through 4 (00H-13H) currently have dedicated hardware functions as defined below.

| Interrupt | Location | Function |
|---|---|---|
| 0 | 00H-03H | Divide by zero |
| 1 | 04H-07H | Single step |
| 2 | 08H-0BH | Non-maskable interrupt |
| 3 | 0CH-0FH | One-byte interrupt instruction |
| 4 | 10H-13H | Interrupt on overflow |

## Interrupt Pointer Table






## iAPX 86/88/186 Instruction Set Matrix

| Hi \ Lo | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 0 | ADD b f r/m | ADD w f r/m | ADD b f r/m | ADD w f r/m | ADD b ra | ADD w ra | PUSH ES | POP ES |
| 1 | ADC b f r/m | ADC w f r/m | ADC b f r/m | ADC w f r/m | ADC b i | ADC w i | PUSH SS | POP SS |
| 2 | AND b f r/m | AND w f r/m | AND b f r/m | AND w f r/m | AND b i | AND w i | SEG ES | DAA |
| 3 | XOR b f r/m | XOR w f r/m | XOR b f r/m | XOR w f r/m | XOR b i | XOR w i | SEG SS | AAA |
| 4 | INC AX | INC CX | INC DX | INC BX | INC SP | INC BP | INC SI | INC DI |
| 5 | PUSH AX | PUSH CX | PUSH DX | PUSH BX | PUSH SP | PUSH BP | PUSH SI | PUSH DI |
| 6 | PUSHA | POPA | -BOUND r,r/m | | | | | |
| 7 | JO | JNO | JB/ JNAE | JNB/ JAE | JE/ JZ | JNE/ JNZ | JBE/ JNA | JNBE/ JA |
| 8 | Immed b r/m | Immed w r/m | Immed b r/m | Immed is r/m | TEST b r/m | TEST w r/m | XCHG b r/m | XCHG w r/m |
| 9 | NOP | XCHG CX | XCHG DX | XCHG BX | XCHG SP | XCHG BP | XCHG SI | XCHG DI |
| A | MOV m→AL | MOV m→AX | MOV AL→m | MOV AX→m | MOVS b | MOVS w | CMPS b | CMPS w |
| B | MOV i→AL | MOV i→CL | MOV i→DL | MOV i→BL | MOV i→AH | MOV i→CH | MOV i→DH | MOV i→BH |
| C | Shift b r/m,i | Shift w,r/m,i | RET (i-SP) | RET | LES | LDS | MOV b r/m | MOV w r/m |
| D | Shift b | Shift w | Shift b v | Shift w v | AAM | AAD | | XLAT |
| E | LOOPNZ/ LOOPNE | LOOPZ/ LOOPE | LOOP | JCXZ | IN b | IN w | OUT b | OUT w |
| F | LOCK | | REP | REP Z | HLT | CMC | Grp1 b r/m | Grp1 w r/m |

where

| mod r/m | 000 | 001 | 010 | 011 | 100 | 101 | 110 | 111 |
|---|---|---|---|---|---|---|---|---|
| Immed | ADD | OR | ADC | SBB | AND | SUB | XOR | CMP |
| Shift | ROL | ROR | RCL | RCR | SHL/SAL | SHR | SHL/SAL | SAR |
| Grp1 | TEST | — | NOT | NEG | MUL | IMUL | DIV | IDIV |
| Grp2 | INC | DEC | CALL id | CALL ind | JMP id | JMP ind | PUSH | — |

— 186 only instruction

## iAPX 86/88/186 Instruction Set Matrix (Cont'd.)

| Hi \ Lo | 8 | 9 | A | B | C | D | E | F |
|---|---|---|---|---|---|---|---|---|
| 0 | OR b f,r/m | OR w f,r/m | OR b f,r/m | OR w f,r/m | OR b i | OR w i | PUSH CS | ! |
| 1 | SBB b f,r/m | SBB w f,r/m | SBB b f,r/m | SBB w f,r/m | SBB b i | SBB w i | PUSH DS | POP DS |
| 2 | SUB b f,r/m | SUB w f,r/m | SUB b f,r/m | SUB w f,r/m | SUB b i | SUB w i | SEG CS | DAS |
| 3 | CMP b f,r/m | CMP w f,r/m | CMP b f,r/m | CMP w f,r/m | CMP b i | CMP w i | SEG DS | AAS |
| 4 | DEC AX | DEC CX | DEC DX | DEC BX | DEC SP | DEC BP | DEC SI | DEC DI |
| 5 | POP AX | POP CX | POP DX | POP BX | POP SP | POP BP | POP SI | POP DI |
| 6 | PUSH iw | IMUL f,rw,i/m | PUSH is | IMUL f,w,r/m | INS b | INS w | OUTS b | OUTS w |
| 7 | JS | JNS | JP/ JPE | JNP/ JPO | JL/ JNGE | JNL/ JGE | JLE/ JNG | JNLE/ JG |
| 8 | MOV b f,r/m | MOV w f,r/m | MOV b f,r/m | MOV w f,r/m | MOV sr f,r/m | LEA | MOV sr f,r/m | POP r/m |
| 9 | CBW | CWD | CALL id | WAIT | PUSHF | POPF | SAHF | LAHF |
| A | TEST b,i | TEST w,i | STOS b | STOS w | LODS b | LODS w | SCAS b | SCAS w |
| B | MOV i → AX | MOV i → CX | MOV i → DX | MOV i → BX | MOV i → SP | MOV i → BP | MOV i → SI | MOV i → DI |
| C | ENTER iw,ib | LEAVE | RET f,(i-SP) | RET f | INT Type 3 | INT (Any) | INTO | IRET |
| D | ESC 0 | ESC 1 | ESC 2 | ESC 3 | ESC 4 | ESC 5 | ESC 6 | ESC 7 |
| E | CALL d | JMP d | JMP r d | JMP si d | IN v,b | IN v,w | OUT v d | OUT v w |
| F | CLC | STC | CLI | STI | CLD | STD | Grp 2 b r/m | Grp 2 w r/m |

b = byte operation
d = direct
f = from CPU reg
i = immediate
ia = immed. to accum.
ib = immediate byte
id = indirect
is = immed. byte sign ext.
iw = immediate word
l = long ie. intersegment
m = memory
r = register
r/m = EA is second byte
si = short intrasegment
sr = segment register
t = to CPU reg
v = variable
w = word operation
z = zero

## Clocks for MOD186 Operation

| FUNCTION | FORMAT | 186 Clock Cycles |
|---|---|---|
| **DATA TRANSFER** | | |
| MOV = Move | | |
| Reg. to reg. | 1 0 0 0 1 0 0 w \| mod reg r/m | 2/12 |
| Reg. to memory | 1 0 0 0 1 0 1 w \| mod reg r/m | 2/9 |
| Immediate to reg. | 1 1 0 0 0 1 1 w \| mod 0 0 0 r/m \| data \| data if w = 1 | 12-13 |
| Immediate to reg. | 1 0 1 1 w reg \| data \| data if w = 1 | 3-4 |
| Memory to accum. | 1 0 1 0 0 0 0 w \| addr-low \| addr-high | 9 |
| Accum. to memory | 1 0 1 0 0 0 1 w \| addr-low \| addr-high | 8 |
| Reg. to segment reg. | 1 0 0 0 1 1 1 0 \| mod 0 reg r/m | 2/9 |
| Segment reg. to reg. | 1 0 0 0 1 1 0 0 \| mod 0 reg r/m | 2/11 |
| PUSH = Push | | |
| Memory | 1 1 1 1 1 1 1 1 \| mod 1 1 0 r/m | 16 |
| Reg. | 0 1 0 1 0 reg | 10 |
| Segment reg. | 0 0 0 reg 1 1 0 | 9 |
| Immediate | 0 1 1 0 1 0 s 0 \| data \| data if s = 0 | 10 |
| PUSHA = Push All | 0 1 1 0 0 0 0 0 | 36 |
| POP = Pop | | |
| Memory | 1 0 0 0 1 1 1 1 \| mod 0 0 0 r/m | 20 |
| Reg. | 0 1 0 1 1 reg | 10 |
| Segment reg. | 0 0 0 reg 1 1 1 \| reg = 01 | 8 |
| POPA = Pop All | 0 1 1 0 0 0 0 1 | 51 |
| XCHG = Exchange | | |
| Reg./memory with reg. | 1 0 0 0 0 1 1 w \| mod reg r/m | 4/17 |
| Reg. with accumulator | 1 0 0 1 0 reg | 3 |
| IN = Input from | | |
| Fixed port | 1 1 1 0 0 1 0 w \| port | 10 |
| Variable port | 1 1 1 0 1 1 0 w | 8 |
| OUT = Output to | | |
| Fixed port | 1 1 1 0 0 1 1 w \| port | 9 |
| Variable port | 1 1 1 0 1 1 1 w | 7 |
| XLAT = Translate byte to AL | 1 1 0 1 0 1 1 1 | 11 |
| LEA = Load EA to reg. | 1 0 0 0 1 1 0 1 \| mod reg r/m | 6 |
| LDS = Load pointer to DS | 1 1 0 0 0 1 0 1 \| mod reg r/m | 18 |
| LES = Load pointer to ES | 1 1 0 0 0 1 0 0 \| mod reg r/m | 18 |
| LAHF = Load AH with flags | 1 0 0 1 1 1 1 1 | 2 |
| SAHF = Store AH into flags | 1 0 0 1 1 1 1 0 | 3 |
| PUSHF = Push flags | 1 0 0 1 1 1 0 0 | 9 |
| POPF = Pop flags | 1 0 0 1 1 1 0 1 | 8 |

## Clocks for MOD186 Operation (Cont'd.)

| FUNCTION | FORMAT | 186 Clock Cycles |
|---|---|---|
| **ARITHMETIC** | | |
| **ADD = Add** | | |
| Reg memory with reg/str to either | 000000dw mod reg r/m | 3/10 |
| Immediate to register memory | 100000sw mod000 r/m data data if s:w = 01 | 4/16 |
| Immediate to accumulator | 0000010w data data if w = 1 | 3/4 |
| **ADC = Add with carry** | | |
| Reg memory with register to either | 000100dw mod reg r/m | 3/10 |
| Immediate to register memory | 100000sw mod010 r/m data data if s:w = 01 | 4/16 |
| Immediate to accumulator | 0001010w data data if w = 1 | 3/4 |
| **INC = Increment** | | |
| Register memory | 1111111w mod000 r/m | 3/15 |
| Register | 01000 reg | 3 |
| **SUB = Subtract** | | |
| Reg memory and register to either | 001010dw mod reg r/m | 3/10 |
| Immediate from register memory | 100000sw mod101 r/m data data if s:w = 01 | 4/16 |
| Immediate from accumulator | 0010110w data data if w = 1 | 3/4 |
| **SBB = Subtract with borrow** | | |
| Reg memory and register to either | 000110dw mod reg r/m | 3/10 |
| Immediate from register memory | 100000sw mod011 r/m data data if s:w = 01 | 4/16 |
| Immediate from accumulator | 0001110w data data if w = 1 | 3/4 |
| **DEC = Decrement** | | |
| Register memory | 1111111w mod001 r/m | 3/15 |
| Register | 01001 reg | 3 |
| **CMP = Compare** | | |
| Register memory with register | 0011101w mod reg r/m | 3/10 |
| Register with register memory | 0011100w mod reg r/m | 3/10 |
| Immediate with register memory | 100000sw mod111 r/m data data if s:w = 01 | 3/10 |
| Immediate with accumulator | 0011110w data data if w = 1 | 3/4 |
| **NEG = Change sign** | 1111011w mod011 r/m | 3 |
| **AAA = ASCII adjust for add** | 00110111 | 8 |
| **DAA = Decimal adjust for add** | 00100111 | 4 |
| **AAS = ASCII adjust for subtract** | 00111111 | 7 |
| **DAS = Decimal adjust for subtract** | 00101111 | 4 |
| **MUL = Multiply (unsigned)** | 1111011w mod100 r/m | |
| Register Byte | | 26–28 |
| Register Word | | 35–37 |
| Memory Byte | | 32–34 |
| Memory Word | | 41–43 |
| **IMUL = Integer multiply (signed)** | 1111011w mod101 r/m | |
| Register Byte | | 25–28 |
| Register Word | | 34–37 |
| Memory Byte | | 31–34 |
| Memory Word | | 40–43 |
| **IMUL = Integer immediate multiply (signed)** | 011010s1 mod reg r/m data data if s = 0 | 22–25/29–32 |
| **DIV = Divide (unsigned)** | 1111011w mod110 r/m | |
| Register Byte | | 29 |
| Register Word | | 38 |
| Memory Byte | | 35 |
| Memory Word | | 44 |



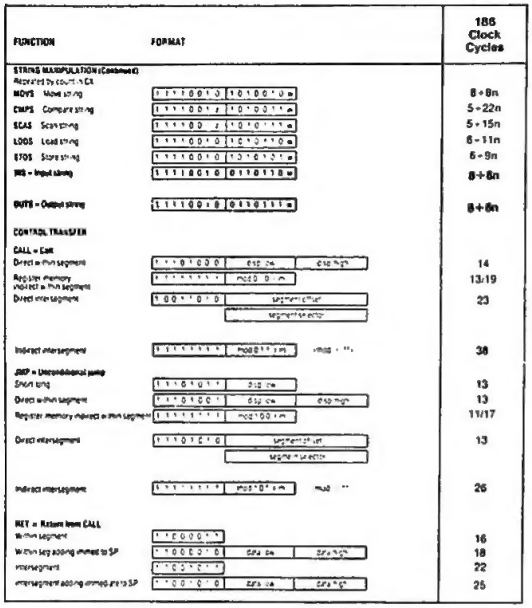
## Clocks for MOD186 Operation (Cont'd.)

| FUNCTION | FORMAT | 186 Clock Cycles |
|---|---|---|
| **ARITHMETIC (Continued)** | | |
| **IDIV** (integer divide (signed)) | 1111011w mod111 r/m | |
| Register Byte | | 44–52 |
| Register Word | | 53–61 |
| Memory Byte | | 50–58 |
| Memory Word | | 59–67 |
| **AAM** ASCII adjust for multiply | 11010100 00001010 | 19 |
| **AAD** ASCII adjust for divide | 11010101 00001010 | 15 |
| **CBW** Convert byte to word | 10011000 | 2 |
| **CWD** Convert word to double word | 10011001 | 4 |
| **LOGIC** | | |
| **Shift/Rotate Instructions** | | |
| Register Memory by 1 | 110100vw mod TTT r/m | 2/15 |
| Register Memory by CL | 110100vw mod TTT r/m | 5 + n/17 + n |
| **Register Memory by Count** | 1100000w mod TTT r/m Count | 5 + n/17 + n |

| TTT | Instruction |
|---|---|
| 000 | ROL |
| 001 | ROR |
| 010 | RCL |
| 011 | RCR |
| 100 | SHL/SAL |
| 101 | SHR |
| 111 | SAR |

| | | |
|---|---|---|
| **AND = And** | | |
| Reg memory and register to either | 001000dw mod reg r/m | 3/10 |
| Immediate to register memory | 1000000w mod100 r/m data data if w = 1 | 4/16 |
| Immediate to accumulator | 0010010w data data if w = 1 | 3/4 |
| **TEST = And function to flags, no result** | | |
| Register memory and register | 1000010w mod reg r/m | 3/10 |
| Immediate data and register memory | 1111011w mod000 r/m data data if w = 1 | 4/10 |
| Immediate data and accumulator | 1010100w data data if w = 1 | 3/4 |
| **OR = Or** | | |
| Reg memory and register to either | 000010dw mod reg r/m | 3/10 |
| Immediate to register memory | 1000000w mod001 r/m data data if s:w = 1 | 4/16 |
| Immediate to accumulator | 0000110w data data if w = 1 | 3/4 |
| **XOR = Exclusive or** | | |
| Reg memory and register to either | 001100dw mod reg r/m | 3/10 |
| Immediate to register memory | 1000000w mod110 r/m data data if s:w = 1 | 4/16 |
| Immediate to accumulator | 0011010w data data if w = 1 | 3/4 |
| **NOT** Invert register memory | 1111011w mod010 r/m | 3 |
| **STRING MANIPULATION** | | |
| **MOVS** Move byte/word | 1010010w | 14 |
| **CMPS** Compare byte/word | 1010011w | 22 |
| **SCAS** Scan byte/word | 1010111w | 15 |
| **LODS** Load byte/wd to AL/AX | 1010110w | 12 |
| **STOS** Stor byte/wd from AL/A | 1010101w | 10 |
| **INS** = Input byte/wd from DX port | 0110110w | 14 |
| **OUTS** = Output byte/wd to DX port | 0110111w | 14 |

## Clocks for MOD186 Operation (Cont'd.)



| FUNCTION | FORMAT | 186 Clock Cycles |
|---|---|---|
| **STRING MANIPULATION (Continued)** | | |
| Repeated by count in CX | | |
| **MOVS** Move string | | 8+8n |
| **CMPS** Compare string | | 5+22n |
| **SCAS** Scan string | | 5+15n |
| **LODS** Load string | | 6+11n |
| **STOS** Store string | | 6+9n |
| **INS** = Input string | | 8+8n |
| **OUTS** = Output string | | 8+8n |
| **CONTROL TRANSFER** | | |
| **CALL** = Call | | |
| Direct within segment | | 14 |
| Register memory indirect within segment | | 13/19 |
| Direct intersegment | | 23 |
| Indirect intersegment | | 38 |
| **JMP** = Unconditional jump | | |
| Short/long | | 13 |
| Direct within segment | | 13 |
| Register memory indirect within segment | | 11/17 |
| Direct intersegment | | 13 |
| Indirect intersegment | | 26 |
| **RET** = Return from CALL | | |
| Within segment | | 16 |
| Within seg adding immed to SP | | 18 |
| Intersegment | | 22 |
| Intersegment adding immed to SP | | 25 |



## Clocks for MOD186 Operation (Cont'd.)

| FUNCTION | FORMAT | 186 Clock Cycles |
|---|---|---|
| **CONTROL TRANSFER (Continued)** | | |
| **JE, JZ** | | 4/13 |
| **JL, JNGE** | | 4/13 |
| **JLE, JNG** | | 4/13 |
| **JB, JNAE** | | 4/13 |
| **JBE, JNA** | | 4/13 |
| **JP, JPE** | | 4/13 |
| **JO** | | 4/13 |
| **JS** | | 4/13 |
| **JNE, JNZ** | | 4/13 |
| **JNL, JGE** | | 4/13 |
| **JNLE, JG** | | 4/13 |
| **JNB, JAE** | | 4/13 |
| **JNBE, JA** | | 4/13 |
| **JNP, JPO** | | 4/13 |
| **JNO** | | 4/13 |
| **JNS** | | 4/13 |
| **LOOP** = Loop control | | 5/15 |
| **LOOPE, LOOPZ** | | 6/16 |
| **LOOPNE, LOOPNZ** | | 5/16 |
| **JCXZ** | | 6/16 |
| **ENTER** = Enter Procedure | | 5 |
| L = 0 | | 15 |
| L = 1 | | 25 |
| L > 1 | | 22+16(n−1) |
| **LEAVE** = Leave Procedure | | 8 |
| **INT** = Interrupt | | |
| Type specified | | 47 |
| Type 3 | | 45 |
| **INTO** = Interrupt on overflow | | 48/4 |
| **IRET** = Interrupt return | | 28 |
| **BOUND** = Detect value out of range | | 33–35 |

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